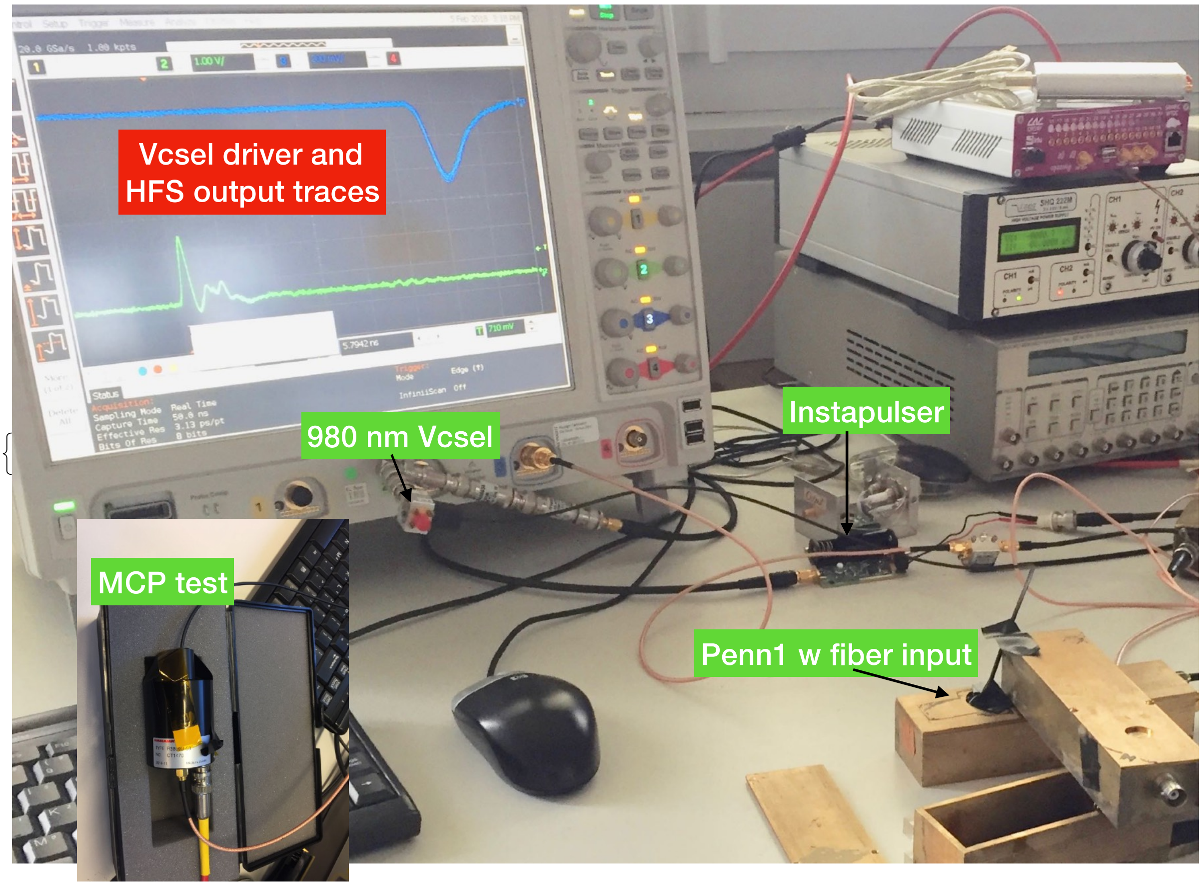
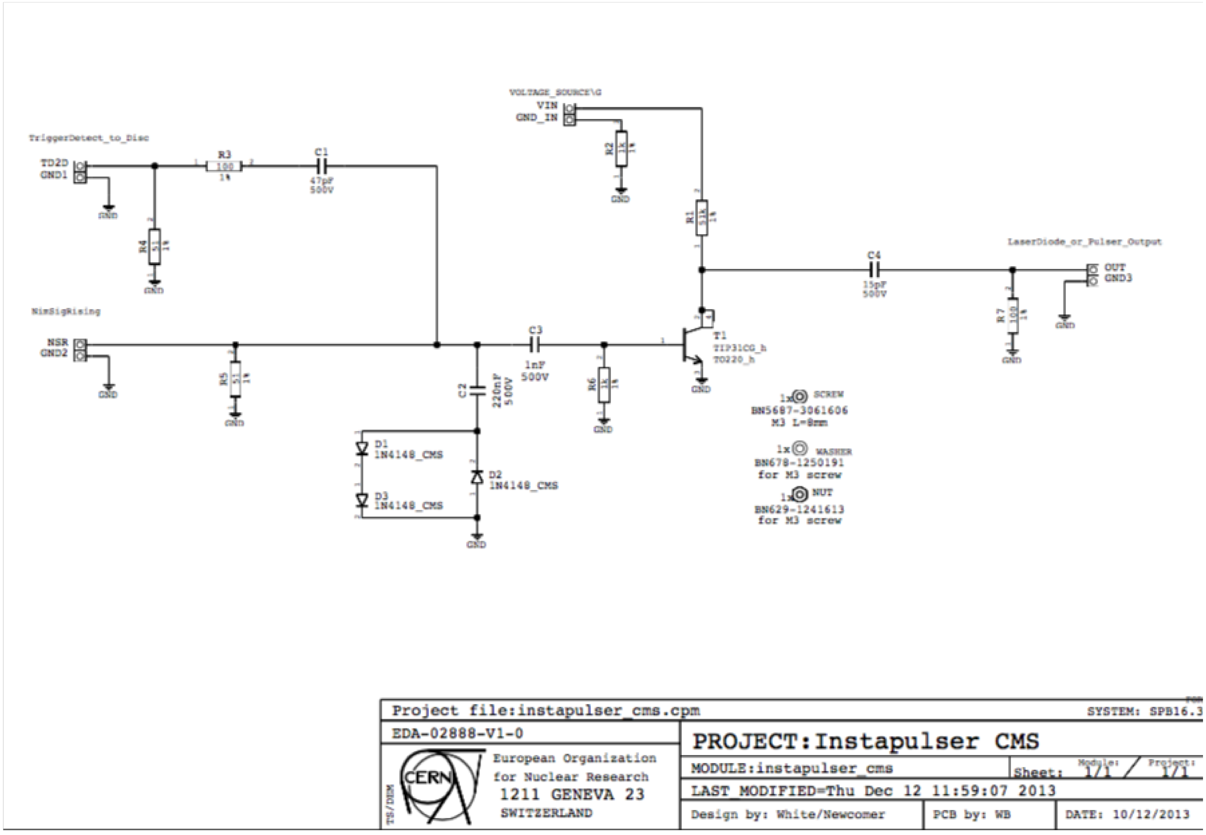
More on the laser test setup for HFS. Here we describe the IR laser setup used to characterize HFS and show a surprisingly good measurement of the time structure using an MCP PMT.

S.White, Feb. 15, 2017

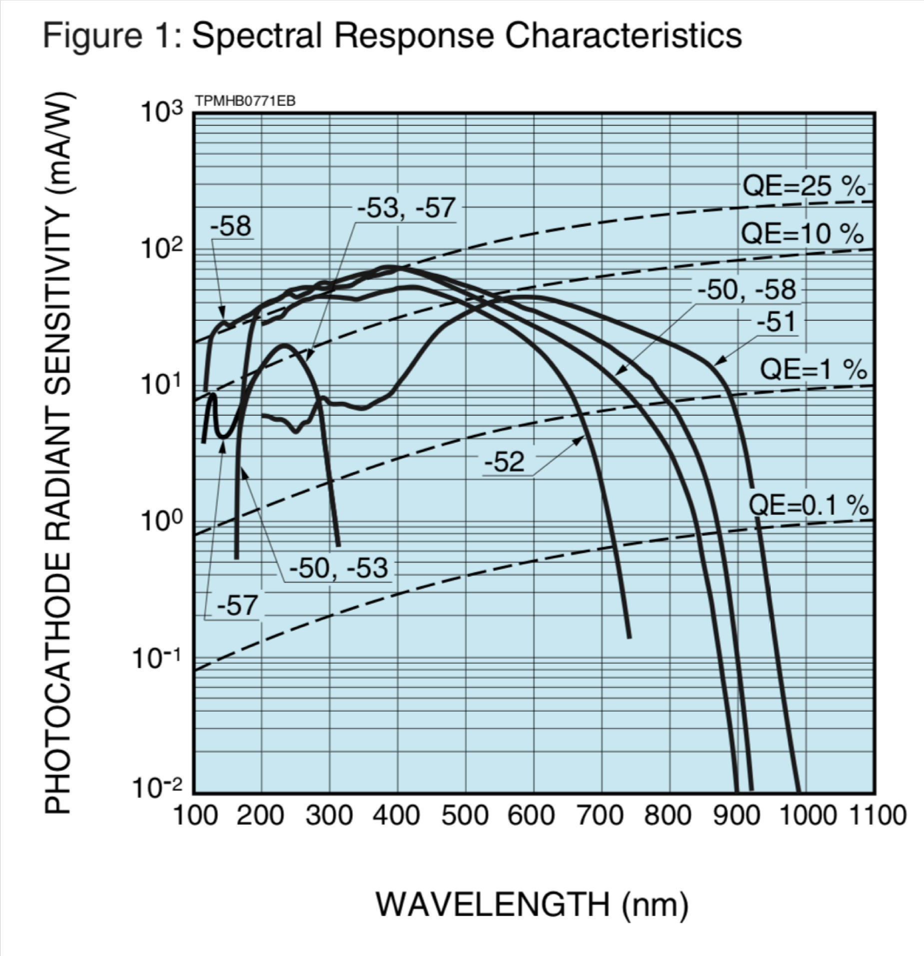
The laser setup is shown in the figure below. An "instapulser", either the one shown in the following schematic (job by me and Mitch, paid for by CMS) or a free - running variant by F. Resnati and F. Brunbauer, drives a ThorLabs VCSEL - 980 nm laser mounted on 1 scope input. The 1 mm optical fiber was used to illuminate the HFS sensor after a variable optical attenuator (used to match the MIP amplitude).





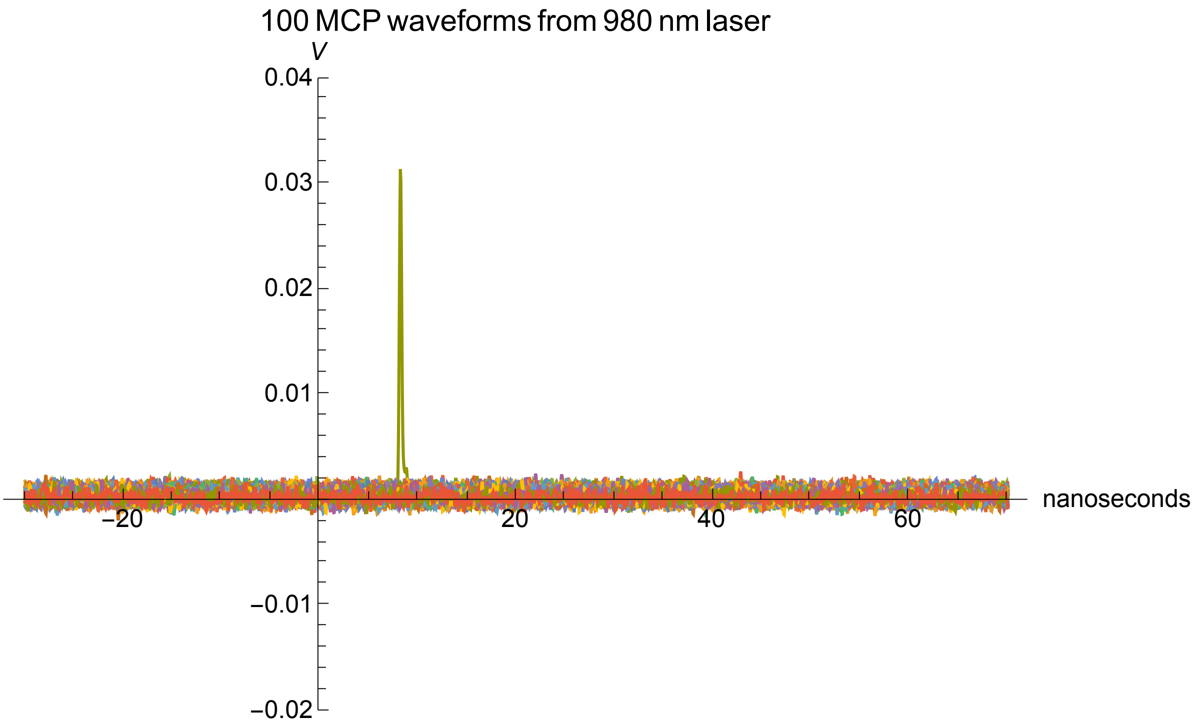
One question that often came up was whether the Vcsel itself introduces any time jitter relative the the pulse that drives it. Sometimes the light pulse is split between 2 identical HFS test devices under test to eliminate this issue but, obviously, it is simpler to just test one device.

I tried as a long shot to use a fast Hamamatsu R3809 - 58 MCP/PMT to measure the structure, even though the below curve tells you that you shouldn't see anything. But because the laser intensity out of the fiber corresponds to ~10^6 photons/pulse, it seemed worth a try anyway. As seen below we had ~1 % efficiency to see 1 photoelectron per pulse and this was enough to say something about the jitter.



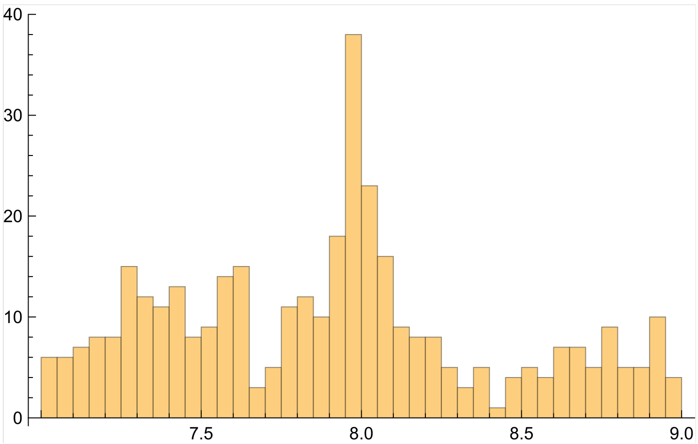
In[38]:=
```
manywaves = Table[waveforms[[i]], {i, 600, 700, 1}];
```

Out[41]=



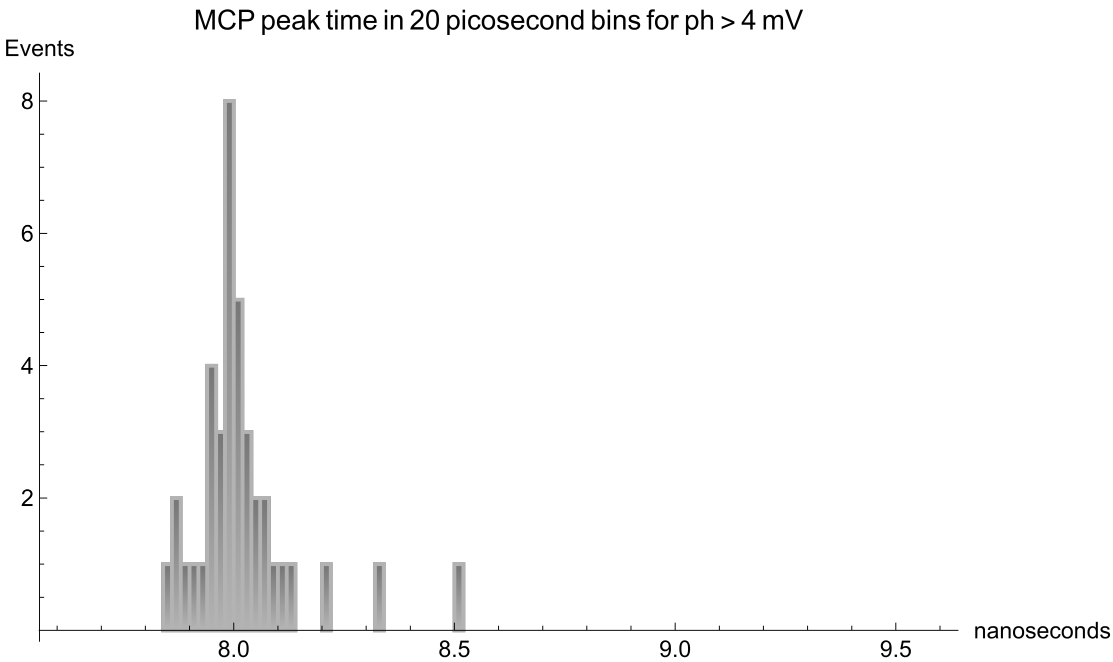
```
pkmcp = Table[Max[vwaves[[i]]], {i, nevents}];
npk = Table[First[Position[vwaves[[i]], pkmcp[[i]]][[1]]], {i, nevents}];
timpk = Table[twaves[[i, npk[[i]]]], {i, nevents}];

Histogram[timpk, {7, 9, .05}]
```

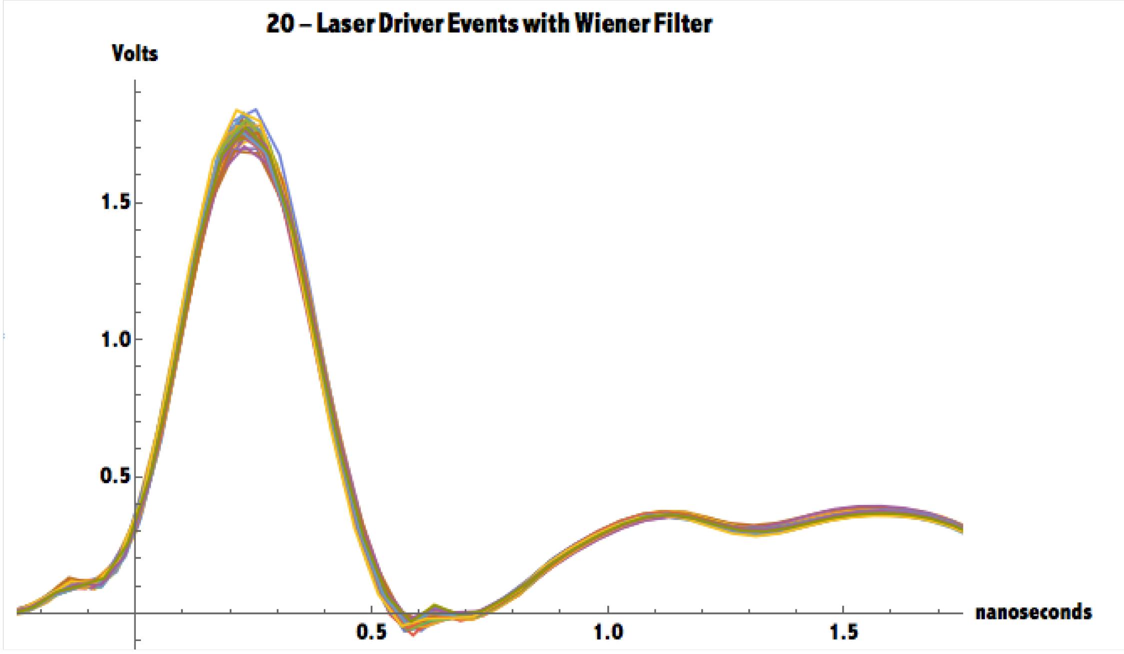
Out[61]=



In[62]:=
```
ntmcp = Transpose[{pkmcp, timpk}];
```

Out[92]=





The above 2 curves (top is the MCP time - simply using peak time sample and bottom is the actual laser drive pulse) on roughly the same time scales shows that the laser jitter is small - almost consistent with the TTS of the MCP/PMT of 25 picoseconds FWHM.

As pointed out by Stefan Simion, the fact that we see any signal may have more to do with broad-band non - coherent light emission from the Vcsel than any residual PMT QE at 980 nm. Thomas Tsang could probably weigh in on this.

Another thing worth noting about the 980 nm wavelength choice is that it is slightly different from the energy deposition profile of a charged particle since the absorption length in Si is 10 % per 10 nm so there is a small drop as youu get near the junction. see below :